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Collaborative Scientific Visualization: The COLLAVIZ Framework

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Abstract

This demonstration introduces new ways and approaches for exploring 3D scientific datasets obtained by numerical simulation. Three main points will be addressed, including compression methods, collaborative virtual environments and features enabling the mix, in the same shared virtual scene, of results given by two different post-processing engines processing the same objects.

Categories and Subject Descriptors (according to ACM CCS): Information Interfaces and Presentation (e.g., HCI) [H.5.1]: Multimedia Information Systems—Artificial, augmented, and virtual realities; Computer Graphics [I.3.2]: Graphics systems—Remote systems; Computer Graphics [I.3.6]: Methodology and Techniques—Graphics data structures and data types

1. Context and goals

We want to use Virtual Reality techniques for collaborative visualization of 3D scientific datasets, to propose new ways to experts to explore and examine scientific datasets. These experts must collaborate in order to make decisions thanks to the sharing of their knowledge, experience and understanding of the simulation. The datasets used for this demonstration are 3D temperature isosurfaces or 3D temperature axial slice cuts, given at several simulation steps, and timestamped from the beginning of the simulation to a time when the simulation does note evolve any longer. The COLLAVIZ prototype will use new compression techniques, and allow users to share in the same virtual scene results coming out of 2 different processing engine: the proprietary leader Ensight and an open source VTK-based alternative.

2. The client helps identifying new usages

The COLLLAVIZ prototype is a semi-rich client based on Java/J2EE and JOGL that enables to validate the key concepts of the COLLAVIZ project in terms of architecture, technologies and performance. It will also provide to the community a first development kit for the development of future tailored clients. Thanks to the standardization of the key interfaces of the whole system and the versatility of the client, it is possible to control, from the same client, different processing engines and apply them on the same data set for similar or complementary processing. In this demonstration, two processing engines are deployed into the platform: Ensight, as close-source application, and Cassandra-PCS, as open-source application on VTK basis. The commands based approach used in the client-platform link allows to include all types of processing engines and pilot them from a unique and unified client. This approach, linked to the future introduction of an additional abstraction layer using a common ontology for the various command language, tends to simplify the use of such processing engines, to extend their domains of application and to facilitate various tailored declinations. In all cases, the outputs of processing are exported in the standard X3D format. Thanks to this choice, the client can merge the results in the same rendering scene for a direct comparison as illustrated figure 1 that displays cutting planes computed with Cassandra-PCS, using VTK as processing layer, and iso-surfaces computed using Ensight. Both are computed on the same initial data set. The correspondence of the color tables confirms the compliance of both results. This opens a large new field of applications. It is now possible to directly compare the result of different processing engines, either to compose their different analysis, i.e. if both engines allow different and complementary processing, or the same result for a direct cross-validation. The http based client-server and the collaboration services allow

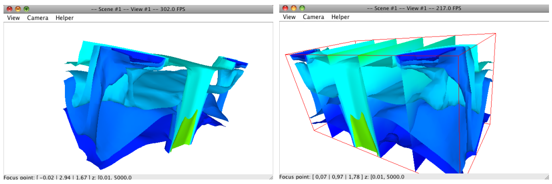

Figure 1: *Multiple isosurfaces and slice cuts from two processing engines*

several remote clients to connect, through firewalls and proxies, to the same platform and to handle remotely the same data in a concurrent manner synchronously. The synchronization is achieved by exchanging a small amount of high level data corresponding to the state of the objects. It allows using poor network infrastructures, like DSL, with a low bandwidth and a risk of high latency. First tests with clients accessing a remote server through DSL networks have already shown the possibility to visualize concurrently large and complex data, shared points of view, 3D markers and actions in the virtual scene with an averaged latency that remains lower than 200ms.

3. A new adaptive data distribution model to fit to network constraints for collaboration

Ensuring that all the users see the same state of a Collaborative Virtual Environment (CVE) at the same time is very important to provide effective collaboration between these users. Absolute consistency is nearly impossible to achieve because it would prejudice the system responsiveness during user interactions. Consequently, existing solutions make a trade-off between consistency and system responsiveness according to their own requirements [FDGA10b]. So we propose a new adaptive data distribution model to reach the best trade-off between consistency and responsiveness according to the requirements of each case and to the network constraints [FDGA10a]. It is based on a referent/proxy paradigm that enables our CVE system to implement three modes of data distribution: centralized, replicated or hybrid. The data distribution mode can be individually chosen for each object according to the function that it fulfills in the virtual environment. Moreover, this data distribution can be dynamically changed during a session to adapt itself to the tasks that users need to perform in the CVE.

4. A valence-driven progressive encoding algorithm to improve performance

In the COLLAVIZ prototype, the compression service is based on a valence-driven progressive encoding algorithm, allowing the progressive decompression of the file. This functionality is particularly useful in the case of remote visualization since it allows to adapt the level of detail to the client device, the network bandwidth and the user needs. Our approach iteratively decimates a set of vertices by combining decimation and cleansing conquests to get different LODs. Our method [LLD10] extends the algorithm from Alliez and Desbrun [AD01] in two ways: our method automatically adapts the quantization for each intermediate mesh so as to obtain a better rate-distorsion performance [LLD09]; second, our method is able to handle colors associated to vertices by introducing an accurate prediction scheme. Hence the mesh is iteratively simplified and at each simplification step, the connectivity, geometry and color information necessary for the inverse operation (i.e. refinement) are encoded. It is naturally decomposed into several parts, one for each level of detail containing connectivity, geometry and color information. The first part is the base mesh which is encoded using a standard mono-resolution compression technique; then each part, together with the already decompressed level, allows to build the next level of detail. On the client side, each LOD is decoded to finally retrieve the original object (lossless compression).

5. Conclusion

The possibility to access in a simple and unified manner to several visualization services opens new possibilities. The remote access through the Web allows analyzing remotely and from a lightweight client potentially very large and complex data. The collaboration features facilitate the cross analysis by co-experts geographically distributed. However, this demonstration remains a first and generic implementation. It aims to address the needs of all tailored application domains and should be considered at the end as the basis of a generic toolkit to facilitate the development of future targeted clients. Last, the demonstration allows 3 concurrent users to collaborate using heterogeneous operating systems: Linux, Windows and MacOS.

Acknowledgements

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